Byproduct formation of TCE abatement: comparison between a plasma-alone and a post-plasma Pd/Al_2O_3 catalytic system

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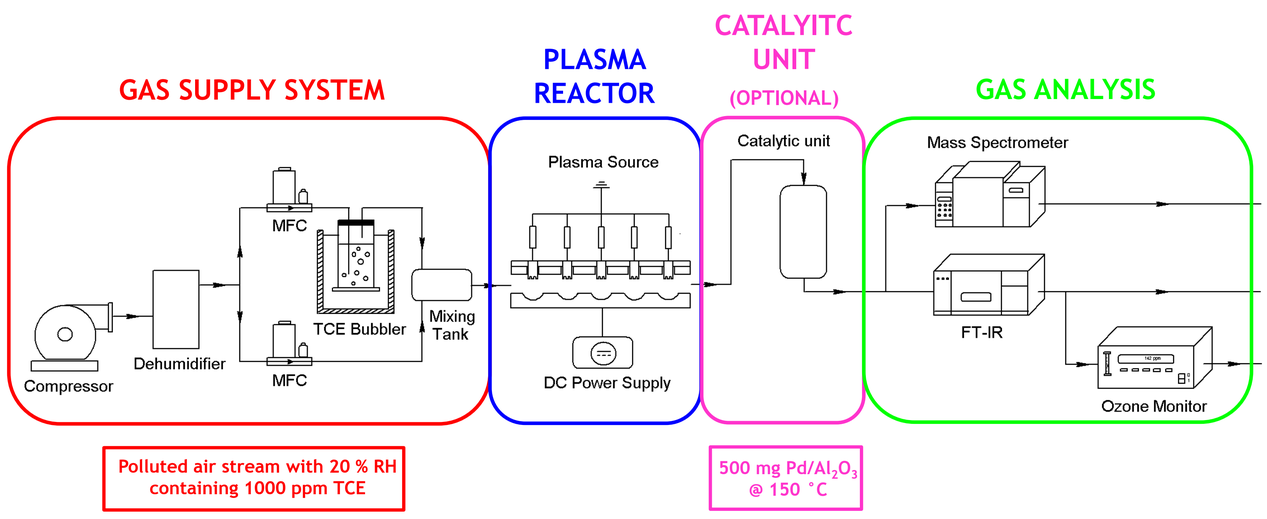
Introduction

Trichloroethylene is a volatile organic compound (VOC) that has adverse effects on the environment and on human health [1]. **Non-thermal plasma** (NTP) generated at **atmospheric pressure**, has proven to be an effective technology to remove VOCs from waste gas streams [2]. The selective acceleration of electrons (1-10 eV) produces radicals through **collisions with background gas molecules** (e.g. N_2, O_2, H_2O) which remain near ambient temperature. These **radicals** are capable of destroying different VOCs simultaneously at a low operating cost. However, the **formation of unwanted byproducts and a low mineralization degree** remain bottlenecks to scale this technique to industrial size [3].
To resolve these weak points, the **combination of NTP with heterogeneous catalysis** has been investigated and has shown to induce a **synergy** in certain hybrid systems. Also, a **higher CO_2-selectivity and energy-efficiency** have been reported [4].
In this study, a DC excited atmospheric pressure glow discharge has been coupled with a catalytic unit downstream to effectively lower the formation of certain unwanted byproducts of TCE abatement which were detected with FT-IR and mass spectrometry.

Experimental set-up

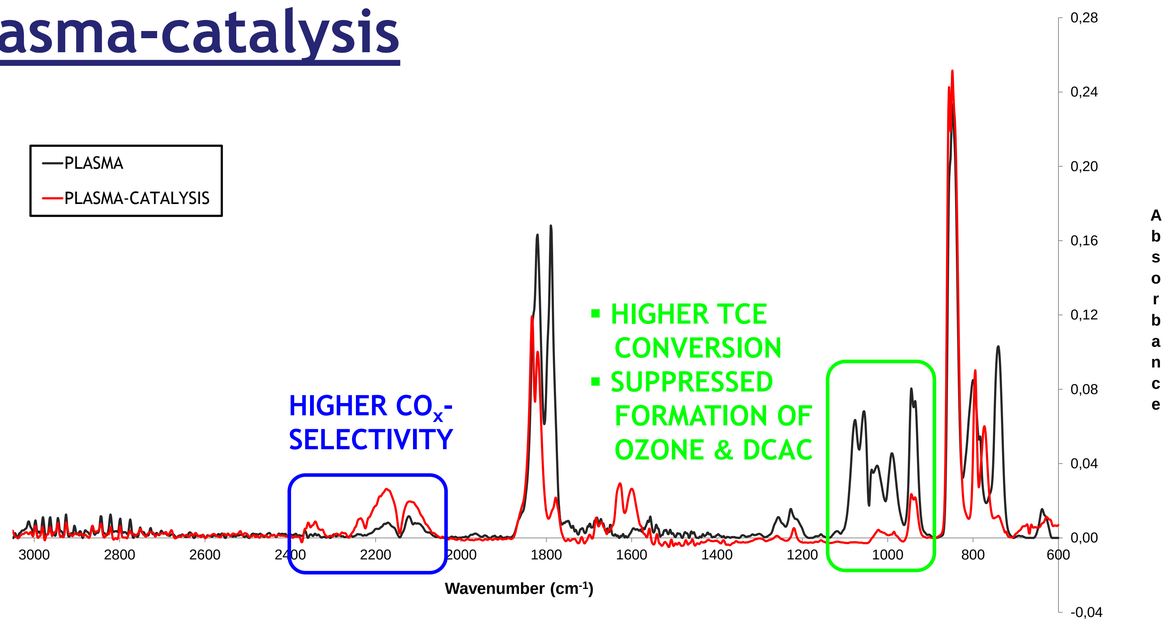


Detected byproducts with NTP

Byproduct	FT-IR	MS	Info
DCAC *	✓	✓	
$COCl_2$	✓	✓	
O_3	✓		Interference
HCl	✓		Interference
CO	✓	✓	
CO_2	✓	✓	
Cl_2		✓	IR transparent
TCAA **		✓	No reference IR spectrum found

*DCAC * : Dichloroacetylchloride TCAA ** : Trichloroacetaldehyde*

Plasma-catalysis



Future work

- Calibration of the FT-IR spectrometer for chlorinated byproducts
- Elucidation of the decomposition scheme of TCE with NTP treatment
- Influence of the initial TCE concentration and air humidity on the removal process
- Tests with other catalysts such as CeO_2-MnO_2

Conclusion

The **NTP treatment** of waste gas containing dilute TCE has led to an **incomplete oxidation** due to the formation of unwanted byproducts such as DCAC, TCAA, phosgene and ozone.
By combining the plasma reactor with a **catalytic unit** downstream, a **higher TCE conversion and CO_x-selectivity** have been obtained while **formation of ozone and DCAC were suppressed**.

References

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[4] Vandenbroucke A.M., Morent R., De Geyter N. and Leys C., J. Hazard. Mater., 195, (2011), 30-54.